Soil forming role of birch in the Ore Mts.

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ABSTRACT: Large areas were deforested as a consequence of the immission calamity in the Czech Republic in the last decades. As a part of restoration activities, preparatory species were utilized, both planted and sown, to cover forest soils, to prevent soil erosion and to regenerate forest microclimate, necessary for reintroduction of target, climax species. Birch (especially *Betula pendula* Roth.) was among the mostly common preparatory species. Presented paper documents the effects of birch in the case of its cultivation on an intact soil. In this case, birch was documented as a species suitable in a short-time perspective, improving soil characteristics and forming effective shelter against increased humus mineralization.

Keywords: immission areas; soil degradation; preparatory species; substitute species; forest soils; soil amelioration; biological amelioration

Forest soil restoration in the immission area of the Ore Mts., especially on the sites with previous bulldozer preparation is still a highly topical problem. The problem has its roots in the immission situation in the 80-ies, which led to the loss of the forest cover in the upper part of Ore Mts. and also to the high soil acidification. Loss of the vegetation cover resulted in organic matter losses and changed the soil chemistry of the forest ecosystems. Also there were shown nutrient losses from the stands due to acid deposition and base leaching. As a substitution of dead and declining spruce stands there were planted different preparatory species such as birch, rowan, and also blue spruce.

Removing of the surface humus led to the nutrients and organic matter loss from the stands and now the data concerning to the plots development and also from the intact plots in the mountain immission areas are in demand. Also the pioneer species influence to the humus forming, nutrients cycling and soil state is not widely known. There were published results (Podrázský 1996; Podrázský et al. 2003) presenting the birch effect to the humus state on the plots with bulldozer site preparation, some other from the afforested agricultural land (Podrázský, Štěpáník 2002) but not from the intact plots.

Aim of this study is to present missing data concerning on the birch effects on the soil and nutrients state and its site conserving function for the plantings, comparing to such functions of the blue spruce on the typical locality of the Ore Mts. on the stand without the bulldozer preparation.

MATERIAL AND METHODS

Humus forms comparison was made on the stands of birch (*Betula pendula* Roth.) and blue spruce (*Picea pungens* Engelm.) on the experimental plot Fláje I (Slodičák, Novák 2001). This stand is situated on the south slope in the altitude of 800 m a.s.l., forest type 7K3 – acid *Fageto-Piceetum acidophilum* – *Calamagrostis villosa*. The main plot consists of three subplots, the humus samples were taken in two variants: blue spruce monoculture and birch

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monoculture. Stand temporary age was 21 years in 2002.

Holorganic horizons (L+F1, F2+H) samples were taken 8. 10. 2002, quantitatively by steel frame 25 × 25 cm, in four replications, analyses were made separately. Samples from the upper mineral horizon (Ah) were taken just qualitatively. Samples processing and chemical analyses were made at Tomáš laboratory (former Forestry and Game Management Research Institute, Forest Research Station Opočno).

Analyses were made for: content and amount of holorganic horizons dry mass, humus and nitrogen content by Springer-Klee (SK) method, LOI – (lost of ignition) content, total nitrogen content by Kjeldahl (Kjel) and Springer-Klee (SK) methods, soil acidity (pH) active (in H_2O leach) and potential (in 1 N KCl leach), exchangeable acidity (also exchangeable aluminium and ex. hydrogen) state, sorption complex characteristics by Kappen (S – base content, H – hydrolytical acidity, T – cation exchangeable capacity, V – sorption complex base saturation), available nutrients content in 1% citric acid solution and total nutrients content by sulphuric acid and selenium compound mineralization. Analyses results were processed by standard one-factor variation analyses at 95% significance level. Statistically significant differences in he results between corresponding horizons on the different plots were in tables subscribed by indexes. If the differences were not significant, the indexes were not indicated.

RESULTS

Herbaceous vegetation stock (Table 1) was higher on the birch plot, regardless of much better light conditions on the blue spruce plot. The difference was not statistically significant up to now. Significantly higher was holorganic layers amount on the birch plot, which sum did reach 156,048 t/ha, in contrast to blue spruce plot, with this value 82,196 t/ha. So it is possible to say, that organic matter stock on the soil surface (consisting of the herbaceous vegetation and humus layers) decreased on the plot with blue spruce. From the soil conservation point of view so the role of blue spruce is minimal and organic matter dynamics is in such stand so close to dynamics on the clear-cuts – with humus mineralization and loss.

Humus content in the L+F1 horizon was also higher (statistically significant difference) on the birch plot, in the deeper horizons (F2+H, Ah) humus content was higher on the blue spruce plot. It documents faster birch litter decomposition and higher biological activity and humification on the birch plot. Content of combustible matter was similar on the both plots studied.

Total nitrogen dynamics was typical (regardless to the determination method – Kjehldahl, Springer-Klee). There was statistically significant difference in favor of birch in the herbaceous vegetation and upper holorganic layers (L+F1), similar contents on the both stands in the deeper horizons with tendency of higher content on the spruce plot. Birch so shows high nitrogen recycling effect, the higher mineralization and nitrogen loss could be expected on the blue spruce plot. Soil acidity active and potential (pH H_2O and pH KCl) in the different horizons had similar trend as nitrogen. Values were higher on the birch plot in litter on contrary in the deeper horizon were below the spruce values. It bears on higher quality of birch litter and on the other hand higher base uptake by birch stand from the deeper horizons.

Table 1. Soil characteristics on research plots in the Fláje area

	Horizon	Dry mass (t/ha)	Humus (SK) (%)	LOI (%)	N (Kjel) (%)	N (SK) (%)	pH H_2O	pH KCl
Birch	herb. veget.	4.084	66.6	89.9	1.45	1.98	5.55	4.52
	L+F1	24.488	64.6 b	88.8	1.95 b	2 b	4.32	3.70
	F2+H	131.56 b	40.6	60.8	1.21	1.13	3.88	3.05
	Ah		21.2	33.2	0.61	0.53	3.3 a	2.78 a
Blue spruce	herb. veget.	3.152	59.7	81.5	1.32	1.7	5.3	4.37
	L+F1	21.608	55.2 a	81.3	1.43 a	1.6 a	4.08	3.50
	F2+H	60.516a	44.2	63.3	1.25	1.14	3.88	3.18
	Ah		22.5	31.4	0.62	0.74	3.75 b	3.02 b

Different indexes indicate statistically significant differences at 95% significance level in corresponding horizon characteristics
Kjel – Kjeldahl method; SK – Springer-Klee method

Soil acidity reflects soil sorption complex state (Table 2). Total exchangeable titration acidity was so higher in the upper (holorganic) horizons on the spruce plot, and higher in the mineral horizon on the birch plot – it reflects mainly the part of exchangeable aluminum capacity. Higher content of exchangeable hydrogen was on the birch plot, which indicates higher degree of soil organic matter humification. Similar trend is observable in the base content example, total exchangeable cation capacity state and soil complex base saturation. Favorable values for the birch stand are documented, except mineral (Ah) horizon. Hydrolytic acidity was relatively equal on the both stands.

As for available nutrients, herbaceous vegetation litter contained higher content of nitrogen, calcium, magnesium on the birch stand, on the other hand also lower phosphorus and potassium content (Table 3). It cohere with favorable birch influence to the upper soil horizons and birch higher demands for some nutrients as potassium and phosphorus respectively, also higher competitive ability of birch for specific nutrient sources (P, K) than vegetation or spruce.

Similar dynamics of plant available nutrients was observed in horizon L+F1, total nutrient content in this horizon was higher on the birch plot. In the bottom holorganic horizon (F2+H) available nutrients content was very similar on the both plots, with trend of higher available potassium and calcium content and lower phosphorus, magnesium and iron content on the birch plot. For the total nutrients content there were no significant differences on the both plots.

Nutrients content in upper mineral horizon Ah was determined only in the plant available form. There were higher contents of nutrients in majority, significantly for iron, except were phosphorus and magnesium content, which were higher on the spruce plot.

Although main part of results has lower statistical significance, there are clear tendencies, which show favorable effects of the birch stand to the nutrient

Table 2. Soil adsorption complex characteristics on the research plot Fláje

Species	Horizon	Exchangeable titration acidity			S base content (mval/100 g)	H hydrol. acidity (mval/100 g)	T cation exch. capacity (mval/100 g)	V sorption compl. rep. (%)
		total mval/kg	H+mval/kg	Al^3+mval/kg				
Birch	L+F1	34.4 a	19.7 b	14.8 a	29.06 b	35.6 b	64.6 b	45.1
	F2+H	74.2	9.7	64.5	11.2	44.8	56	20.2
	Ah	81.4	7.3	74.2	4.73	23.2	26.5	17.2
Blue spruce	L+F1	61.4 b	11.6 a	49.8 b	18.2 a	36.2	54.3 a	34
	F2+H	87.4	7.1	80.5	10.4	43.4	53.8	19.4
	Ah	78.6	5	73.6	5.7	22.1	27.8	20.4

Different indexes indicate statistically significant differences at 95% significance level in corresponding horizon characteristics

Table 3. Nutriet content in herb layer and in particular horizonts on plots in the Fláje area

Species	Horizon	Available nutrients (by 1% citric acid) (mg/kg)					Total nutrients (%)				
		P_2O_5	K_2O	CaO	MgO	Fe_2O_3	N	P	K	Ca	Mg
Birch	veget.	1,135	5,873	5,734	1,526	184	1.58	0.11	0.42	0.38	0.2
	L+F1	600	1,800	5,733	952	299	1.94 b	0.11	0.22	0.18	0.07
	F2+H	252	507	1,660	215	1,390	1.13	0.07	0.23	0.01	0.02
	Ah	167	284	658	76	1,668 a					
Blue spruce	veget.	1,218	6,524	4,622	908	223	1.48	0.12	0.59	0.24	0.1
	L+F1	511	1,020	3,260	419	842	1.46 a	0.1	0.17	0.04	0.03
	F2+H	259	465	1,340	236	1,702	1.19	0.1	0.2	0.01	0.02
	Ah	210	254	567	80	3,509 b					

Different indexes indicate statistically significant differences at 95% significance level in corresponding horizon characteristics state in the soil upper horizons. Birch recycles effectively low content nutrients and its litter has favorable effect for humus forms forming.

DISCUSSION AND CONCLUSIONS

Results confirmed favorable effect of birch to the soil state and its high ameliorative effect as a preparatory species. On the other hand they proved the low effects of the blue spruce stand to the soil protection and soil fertility regeneration. Results on the intact (without heavy mechanization preplanting preparation) were similar as on the stands with bulldozer soil preparation or sheet ploughed stands (Moravčík, Podrázský 1993; Podrázský 1996; Podrázský et al. 2003). Also alike results were obtained in the case of reforestation of former agricultural lands in the experiment with monitoring different species effects to the soil. In that case birch had good ameliorative effect, red oak influence was low, spruce mildly degradation and larch had clearly degradation effect to the soil (Podrázský, Štěpáník 2002). There was also proved blue spruce degradation effect of soil state and very low effect to the soil protection and conservation in the immission areas (Podrázský 1997).

For the future utilization of the birch and blue spruce stands there are follow-up recommendations:

(a) maximal utilization of the ameliorative and soil protective effects of the birch stands, and the use of birch as a species for under-plantings of climax species. Partial birch presence in the stand composition after stands reconstruction is also potential, but the appropriate provenance and clone selection would be essential. In the case of under-plantings of the preparatory stands by nutrient more demanding species (beach, fir) fertilization has to be used. It is urgent to apply under-plantings appropriately and fast at the older stands of birch, because of this species is relatively short living. There is possible to use mixed stands of birch and spruce (*Picea abies* [L.] Karst.), with spruce as a preparatory species – for the faster humus accumulation on the stands with past bulldozer preparation;

(b) blue spruce stands have not high utilization, excepts for inter-plantings as stands with protective effects against the game browsing. Also in this case the fast tending is urgent presumption, because of this species negative effect to the soil state and conservation.

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Půdotvorná role břízy v Krušných horách

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ABSTRAKT: V České republice byla v posledních desetiletích obnovena v důsledku imisní kalamity rozsáhlá území. Jako součást obnovních strategií byly využívány i náhradní dřeviny, obnovené sadbou i síjí, s cílem pokrýt lesní půdy, zabránit půdní erozi a regenerovat lesní prostředí, nezbytné pro reintrodukci cílových, klimaxových dřevin. Bříza, respektive bříza bradavičnatá (*Betula pendula* Roth.), byla jednou z nejčastěji používaných náhradních dřevin. Příspěvek dokládá její vliv na intaktní, nenarušenou půdu ve srovnání se smrkem pichlavým. V tomto případě se ukázala jako dřevina s příznivými účinky, zlepšující stav půd a vytvářející účinný ekologický kryt proti mineralizaci humusu.

Klíčová slova: imisní oblasti; degradace půd; přípravné dřeviny; náhradní dřeviny; lesní půdy; meliorace; biologická meliorace

Obnova lesních půd v imisní oblasti Krušné hory představuje významný problém pro další vývoj lesního hospodářství dané oblasti. Na plochách postižených imisní kalamitou a následným nevhodným použitím některých technologií má důležitou úlohu bříza, zejména bříza bradavičnatá (*Betula pendula* Roth.), a to jak na plochách s tzv. buldozerovou přípravou, tak i na lokalitách s intaktní vrstvou nadložního humusu. Příspěvek srovnává stav humusových forem v porostech břízy a smrku pichlavého na výzkumné ploše Výzkumného ústavu lesního hospodářství, Výzkumné stanice Opočno, typické pro širokou oblast Krušných hor s nenarušeným nadložním humusem. Stanoviště je situováno na J svahu v nadmořské výšce zhruba 800 m, LT je určen jako 7K3 – *Fageto-Piceetum acidophilum* – *Calamagrostis villosa.* Věk porostu byl v roce 2002 21 let. Vzorky byly odebírány ve čtyřech opakováních z jednotlivých vrstev nadložního humusu (L+F1, F2+H) – kvantitativně – a z nejsvrchnějšího, humusem obohaceného minerálního horizontu Ah – pouze na stanovení kvality – na podzim roku 2002.

Byla stanovena zásoba sušiny holorganických horizontů, dále obsah celkového dusíku a uhlíku, půdní reakce aktivní i výměnná, charakteristiky sorpčního komplexu podle Kappena (S – obsah výměnných bází, H – hydrolytická acidita, T – kationtová sorpční kapacita, V – nasycení sorpčního komplexu bázemi), přístupné makroživiny ve výluhu 1% kyselinou citronovou a obsah celkových živin po mineralizaci směsí kyseliny sírové a selenu. Výsledky byly zpracovány standardní jednofaktorovou analýzou variance na 95% stupni významnosti.

Výsledky (shrnuté v tab. 1–3) potvrdily příznivý vliv břízy na stav půd a její vysoký meliorační efekt na rozdíl od smrku pichlavého (stejně jako v dřívějších studiích na buldozerových plochách). Pod břízou byly doloženy vyšší zásoby biomasy buřeně s vyšším obsahem živin. Zásoba nadložního humusu s výrazně příznivějším stavem dosáhla pod břízou 156 048 t/ha, pod smrkem pichlavým pouze 82 196 t/ha (tab. 1). Bříza tedy brání nadměrné mineralizaci nadložního humusu a ztrátám živin a tvoří holorganické vrstvy s mnohem příznivějším chemicko-biologickým stavem. Obsah dusíku byl pod porosty břízy rovněž vyšší v povrchových vrstvách a v buřeni, hlouběji byl srovnatelný. To dokládá vysokou schopnost břízy recyklovat dusík a bránit jeho ztrátám z ekosystému. Stejným směrem byla ovlivněna dynamika celkového uhlíku, pH a půdní acidita. Příznivý vliv břízy byl doložen i v případě charakteristik půdního sorpčního komplexu (tab. 2).

Humusové formy pod břízou vykazovaly vyšší obsah dusíku, vápníku a hořčíku, nižší pak v případě fosforu a draslíku – tyto živiny byly selektivně přijímány břízou ve zvýšené míře. Bříza ovlivnila příznivější obsah celkových i přístupných živin ve svrchních horizontech humusových forem, hlouběji byly hodnoty obsahu podobné. Pod smrkem došlo k výrazné mobilizaci železa v přístupné formě (tab. 3). V budoucnu se jako hlavní princip dalšího managementu obou typů porostů objevuje možnost využití příznivého vlivu břízy na stav lesních půd a vnosu klimaxových dřevin formou podsadeb, u porostů smrku pichlavého pak nutnost do nich prosadbami vpravit funkčně účinnější složku.

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